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A SOCIAL PERSONALIZED ADAPTIVE E-LEARNING ENVIRONMENT: A CASE STUDY IN TOPOLOR

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ABSTRACT

Adaptive e-Learning is a process where learning contents are delivered to learners adaptively, namely, the appropriate contents are delivered to the learners in an appropriate way at an appropriate time based on the learners' needs, knowledge, preferences and other characteristics. Social e-Learning is a process where connections are made among like-minded learners, so they can achieve learning goals via communication and interaction with each other by sharing knowledge, skills, abilities and materials. This paper reports an extended case study that investigated the influence of social interactions in an adaptive e-Learning environment, by analyzing the usage of social interaction features of a Social Personalized Adaptive E-Learning Environment (SPAEE), named Topolor, which strives to combine the advantages from both social e-Learning and adaptive e-Learning. We present the results of a quantitative case study that evaluates the perceived usefulness and ease of use. The results indicated high satisfaction from the students who were using Topolor for their study and helped us with the evaluation processes. Based on the results, we discuss the follow-up work plan for the further improvements for Topolor.

KEYWORDS

Adaptive hypermedia, adaptive educational hypermedia, personalization, adaptive e-Learning, social e-Learning, social interaction, evaluation.

1. INTRODUCTION

The new generation learners are no longer satisfied with being passive consumers. Instead, they 'increasingly satisfy their desire for choice, convenience, customization, and control by designing, producing, and distributing products themselves' (Tapscott and Williams, 2007). These new developments follow the developments of the Internet and World Wide Web, especially the area called social media, based on ideological and technological foundations of Web 2.0. Social media applications allow for the creation and

exchange of user generated content like never before (Kaplan and Haenlein, 2010). In this context, new types of learning environments have emerged, where learners can interact with others and engage in effective and attractive learning experiences (Welsh *et al.*, 2003). E-Learning experts see a lot of potential for learning in this area, as the various social features such as sharing, tagging, rating, commenting can be applied in e-Learning systems and thus can offer new opportunities for communication, collaboration, and active participation in the learning process (McLoughlin and Lee, 2011). Discussions and group work are often integrated into collaborative and participative learning practice, providing a range of educational benefits, which are thoroughly discussed in the literature (e.g. Hrastinski (2009), Brady *et al.* (2010) and Bennett *et al.* (2012)).

Meanwhile, Adaptive Educational Hypermedia (AEH) systems (Brusilovsky, 2003) (e.g., AHA! (Cristea *et al.*, 2007), MOT2.0 (Ghali and Cristea, 2009a) and GALE (De Bra *et al.*, 2012)) utilize Adaptive Hypermedia techniques to tailor online courses according to the needs of the individual user. Adaptation involves the definition and continual maintenance of a User Model (Brusilovsky, 2001). AEH systems use such a user model to decide how to personalize the content, according to a range of characteristics, taking into account aspects such as learning goals, background knowledge and preferences (Van Rosmalen *et al.*, 2009). Moreover, an adaptive system continually refines the user model according to the user's interactions within the AEH system.

Brusilovsky (2001) – and later Knutov *et al.* (2009) – classified the personalization techniques utilized in Adaptive Hypermedia into three broad areas:

- *Content Adaptation Techniques*: Changing the content of a particular learning resource such as a webpage.
- *Adaptive Presentation Techniques*: Changing the way a learning resource is presented (for example, changing the layout of the system).
- *Adaptive Navigation Techniques*: Providing personalized navigation by changing the ways that hyperlinks are presented and/or recommended to the user.

However, none of these adaptation techniques takes into account any information about the user's social connections. Indeed, the review of the previous work indicates that current e-Learning systems have only marginally explored the integration of social interaction features and adaptation techniques. Therefore combining the benefits offered by existing AEH systems with the social affordances of Web 2.0 tools, offers a great potential to improve e-Learning systems and learning experiences. Hence, the research presented in this paper intends to address this gap by evaluating a system that was developed to foster effective social and adaptive e-Learning experiences.

The aim of this research is to improve the learning experience and learning outcomes via a social adaptive learning paradigm, based on the hypothesis that *extensive social features, personalized recommendations and Facebook-like appearance of a system (anticipated to make the environment more familiar to learners), subsequently increases the usefulness and usability of the system*. We have evaluated Topolor from various perspectives (Shi *et al.*, 2013a; Shi *et al.*, 2013b, Shi *et al.*, 2013c). In order to isolate research variables, this paper focuses exclusively on studying the *usefulness* and *ease of use* of the social features in an adaptive personalized social e-Learning environment. It is based on our previous quantitative case study that explores the use of Topolor – a Social Personalized Adaptive E-Learning Environment (SPAEE) (Shi *et al.*, 2013d). This paper uses Topolor for an extended a case study to investigate the social interaction within an adaptive e-Learning environment. The paper presents the results of analysis of the usage of social interaction features of Topolor, which strives to combine the advantages from both social e-Learning and adaptive e-Learning (Shi *et al.*, 2013e).

The rest of paper will start by reviewing the related research, depict the social interaction tools in Topolor, and then present the conducted experiment and its results. Finally, the conclusions and the outline of future work will be described.

2. RELATED RESEARCH

Learning is intrinsically a social endeavor (Bandura, 1977; Zimmerman, 1989; Wenger, 2000) Social facets of learning have been described in a variety of theoretical frameworks about people and their learning (e.g., (Vygotsky, 1978), (Wenger, 2009) and (Dabbagh and Kitsantas, 2012)). However, moving from the face-to-face experience into the computerized domain, the creation of effective and efficient online social learning

remains an unsolved problem. Whilst online exchange via social networking is immensely popular and an important component of day-to-day life, providing solutions that foster creation of effective e-Learning spaces are not straightforward.

In parallel with the development of social e-Learning platforms, a variety of AEH-based learning tools have also been researched (Brusilovsky, 2004). For instance, AHA! (De Bra *et al.*, 2003), was designed as an adaptive hypermedia platform, which delivers XHTML pages as a series of concepts. Each concept is recommended to the user according to a predefined adaptation strategy. Content for AHA! needs to be authored using either the AHA!-specific 'Graph author' tool, or using external tools such as MOT3.0 (Foss and Cristea, 2010). More recently, the GRAPPLE (De Bra *et al.*, 2013) project created the GALE (Smits and De Bra, 2011) delivery engine, which extended the principles of AHA! to produce a more general purpose (and fully extendable) delivery engine. The GRAPPLE project also created a set of authoring tools to allow educators to specify how adaptation should be applied to their learning materials (Foss and Cristea, 2011). However, although these adaptation engines and authoring tools are very generic and support possibly all the types of adaptive hypermedia to date, they do not allow the same support for social interaction, as we do in our system, Topolor.

Social navigation has been proposed as one of the first attempts to combine adaptation with social learning (Dieberger *et al.*, 2000; Brusilovsky *et al.*, 2004). A more recent research was MOT2.0 (Ghali and Cristea, 2009c.), which went a little further in terms of social features incorporated - it provides features to allow students to chat, comment, rate and tag parts of the learning content. This allowed the system to provide adaptive navigation personalization techniques, by suggesting content that the learner's peers had recommended, as well as suggesting appropriate peers to contact. An interesting technique also used by this system is that of adaptive rights: i.e., rights adapted to the deduced level of the user. However, this system was still at a level of proof of concept, and the granularity of its adaptation, as well as its social interaction was quite coarse (e.g., complete topics were recommended, the peer recommendation was relatively simple, etc.). This work thus was the basis for the work presented here, where much more fine-grained adaptation and recommendations, as well as fine-grained social interactions are introduced.

Since the early 2000s, many theoretical AH frameworks have been proposed, such as AHAM (Wu, 2002), XAHM (Cannataro *et al.*, 2002), LAOS (Cristea and De Mooij, 2003), the Munich model (Koch and Wirsing, 2006) and GAF (Knutov, 2008). These frameworks were designed to simplify the process of building adaptive systems. Some of these models were later extended to accommodate some social features. For example Social LAOS (SLAOS) (Ghali and Cristea, 2009b) added a collaboration mechanism to the LAOS framework, and led to the development of the MOT 2.0 system (Ghali and Cristea, 2009c). MOT 2.0 introduced, as said, social features such as a chat tool, tagging, rating and commenting on learning content. The results from its evaluation showed that all the social features were overall appreciated as being useful (Cristea and Ghali, 2009) in an adaptive e-Learning context.

However, while these systems cater for personal needs within specific learning contexts, they are often limited in their strategies for adapting to social needs or in their social features. Some recent works (Šimko *et al.*, 2010; Harris *et al.*, 2011; Wong and Looi, 2012) have already proposed the need for creating adaptive and highly interactive integrated learning environments. However, their work suggests only a limited number of mechanisms for enabling social interaction. Hence, there is a gap for extending and evaluating social interaction tools in adaptive e-Learning settings. Additionally, the familiarity of a user interface is important in the user-system interaction design, as it can shorten users' reaction time, and therefore reduce their burden of getting used to using the system (Lim *et al.*, 1996). However, existing frameworks do not take into account the role of learner familiarity with other social interaction tools from e-Learning environments and social networking websites, such as Facebook. Our research indicates that when students start to use a new e-Learning system, they are inclined to explore every single available operation rather than focusing on the learning itself, which may not necessarily be a bad thing, because it is normal to try and get familiar with the environment, which can be helpful for their later learning, but from the research point of view, it would be better that we made the newly tested tools more familiar to the students, so that the usage data we collected are reflecting the long term use (Shi *et al.*, 2013h). In fact, the features that many of the learners are familiar with from social networking websites remain missing from the current e-Learning systems. For instance, sharing a learning status, engaging in a simple question/answer exchange and sharing notes remain cumbersome or impossible in many of the available systems. Subsequently, the potential of adaptation, recommendation and personalization that is based on the use of the above social features remains largely unexplored.

In this paper we address the above gap by introducing and evaluating a range of social features previously missing from the available adaptive e-Learning systems.

3. TOPOLOR: A SOCIAL PERSONALIZED ADAPTIVE E-LEARNING ENVIRONMENT

In order to validate the hypothesis on which our work is built (Section 1), and further based on our experiment of requirement analysis (Shi *et al.*, 2012a; Shi *et al.*, 2012b), we have developed a Social Personalized Adaptive E-Learning Environment (SPAEE), Topolor (Shi *et al.*, 2013d), which was built on the Yii Framework¹ and Bootstrap². Topolor has been made available open source and hosted on Github³ for easy sharing and version control. It is deployed⁴ and used as an online learning environment to support postgraduate level modules in the Department of Computer Science, at the University of Warwick, and the usage data are being anonymously collected for analysis. The registration for using Topolor has been also opened to public. Thereafter, a larger cohort of users is expected in the near future, providing opportunities for collecting feedback, usage data and suggestions for further improvements.

Topolor mainly consists of three sub-systems. Each of them contains a set of interaction features that are generally referred to here as the social interaction toolset (Shi *et al.*, 2013e). The subsystems of Topolor and its main services are as follows:

- *Topolor-Home* provides a chronological list of the posts shared by the students. They can share learning status, ask and answer questions, repost a learning status and questions, and so on. It also provides access to the interaction tools that encourage informal communication and collaboration such as commenting on, sharing and 'favourite'-ing learning statuses, and send messages to each other, as shown in Figure 1.

Module Center offers a warehouse of online modules, and provides learning content recommendation, learning path recommendation, learning peer recommendation, and interaction tools that encourage personalized social e-Learning such as sending messages to recommended learning experts.

Figure 3 shows the module dashboard, where learners can check the module structure, go to the recommended concept page, review the concepts learnt, review the quiz and questions, comment on the module, ask and answer questions related to the module, contact other learners who are learning the same module, and so on.

- Figure 2 shows the concept learning page, where learners can learn the concept, navigate to other related concepts, contact recommended learning expert on this concept, comment on the concept, ask and answer questions related to this concept, take a note and make a task related to this concept, and so on.

Q&A Centre maintains various lists of questions/answers related to the learning contents, and provides adaptive question recommendation, concept recommendation, and expert learner recommendation and so on for the personalized adaptive e-Learning, as shown in

- Figure 4. In the Q&A Centre, learners can switch between different ways of sorting questions, such as the questions sorted by the time they were asked, the number of answers, the number of times each question has been shared, the number of times the question had been 'favourite'-d, and so on. Learners can also find which concepts have more questions asked, hence they can switch between different concepts; and which tags have more questions shared, hence they can visit the concept page that has the most popular tag(s).

Quiz Service delivers quizzes automatically, namely, when learners view the concept page, they can click on the 'take a quiz' button, and then Topolor randomly chooses a number of questions, which the learner has not answered before, to generate a quiz related to the concept, as shown in Figure 7. After submitting the quiz,

Topolor directly sends a feedback to the learners, showing which questions were correctly or incorrectly answered, as shown in

- Figure 5. Afterwards, learners can check their own quiz list, which indicates the number of questions correctly and incorrectly answered for each quiz, as shown in Figure 6, and they can click on the 'review' button to see the details of the quiz. Furthermore, beside each question, there is information about which

1 <http://yiiframework.com>

2 <http://twitter.github.com/bootstrap>

3 <https://github.com/aslanshek/topolor>

4 <http://www.topolor.com>

concept and which tags are related to this question, so that learners are able to review the related concepts.

The image displays the home page of the Topolor platform, which is designed for collaborative learning. The interface is organized into three main vertical sections:

- Left Sidebar:** Features a user profile for 'shilei' with statistics (Shared: 3, Commented: 4, Favourites: 3). Below this is a 'News Feed' with icons for Messages, Q&As, Notes, and To-Do. A 'MY MODULES' section lists 'Collaborative Filtering' and 'لغة البرمجة بايثون'. A 'TOP USERS' list shows users like alexandra, yangq, shilei, dana, and lei with their share counts.
- Central Main Content Area:** Includes a 'Status' bar with options for Message, Q&A, Note, and Todo. Below this is a feed of user posts:
 - A post by 'shilei' stating 'I share this note for you guys :)' with a note titled '@shilei: test creating a note' from 12/08 10:24 PM.
 - A question from 'jonny' asking 'I haven't used tags in questor' from 11/30 09:35 AM.
 - A question from 'adtsakai' asking 'Quiz, question 3:' from 11/29 11:51 AM.
 - A post from 'robin' re-sharing a note about getting coffee from 11/29 11:50 AM.
- Right Sidebar:** Contains educational content for the 'Collaborative Filtering' module. It includes an 'Introduction' section with links to 'Core Concepts', 'The Beginning of CF', 'CF and Adaptive Web', 'Uses for CF', 'User Tasks', and 'V.S. Content-Based Filtering'. Below this is a 'Take a test' button, a 'Tag' section with various tags like 'introduction', 'challenge', 'rating', etc., and a 'User Tasks' section with a 'Start' button. At the bottom, a 'Recently Learnt' section shows 'CF and Adaptive Web' as a recently learned concept.

Figure 1 Home page

The screenshot shows the 'Concept' page for 'Collaborative Filtering > CF and Adaptive Web' on the Topolor platform. The page is dated 'Learnt at: Jan 17, 2013'. It features a 'Review the Quiz' button and navigation links for 'Previous' and 'Next'. The main content area includes a 'Tag' section with 'adaptive web', 'comparison', 'explicit', 'limitation', and 'prediction'. The text explains that early collaborative filtering systems were designed to provide users with information about items they visited, and that providers of information on the web must deal with limited user attention and limited screen space. It also mentions that collaborative filtering enables the web to adapt to each individual user's needs. The page includes a 'Comments (2)' section with a 'Q&As (2)' tab, showing a question from 'shilei' about 'Adaptive Web and Recommendation Web' and a 'My answer' section. The left sidebar shows the user's profile 'shilei' with 'My modules: Learning 14' and 'Learnt: 7', recommended concepts like 'Explicit v.s. Implicit Ratings' and 'Social Navigation', top users, and study buddies.

Figure 2 Concept page

The screenshot shows the 'Module dashboard' page for 'Collaborative Filtering > Quiz list' on the Topolor platform. The page is dated 'Learnt at: Jan 17, 2013'. It features a 'Review the Quiz' button and navigation links for 'Previous' and 'Next'. The main content area includes a 'Tag' section with 'adaptive web', 'comparison', 'explicit', 'limitation', and 'prediction'. The text explains that early collaborative filtering systems were designed to provide users with information about items they visited, and that providers of information on the web must deal with limited user attention and limited screen space. It also mentions that collaborative filtering enables the web to adapt to each individual user's needs. The page includes a 'Comments (2)' section with a 'Q&As (2)' tab, showing a question from 'shilei' about 'Adaptive Web and Recommendation Web' and a 'My answer' section. The left sidebar shows the user's profile 'shilei' with 'My modules: Learning 14' and 'Learnt: 7', recommended concepts like 'Explicit v.s. Implicit Ratings' and 'Social Navigation', top users, and study buddies.

Figure 3 Module dashboard page

The screenshot shows the 'Q&A Center' page on the Topolor platform. The page is dated 'Learnt at: Jan 17, 2013'. It features a 'Review the Quiz' button and navigation links for 'Previous' and 'Next'. The main content area includes a 'Tag' section with 'adaptive web', 'comparison', 'explicit', 'limitation', and 'prediction'. The text explains that early collaborative filtering systems were designed to provide users with information about items they visited, and that providers of information on the web must deal with limited user attention and limited screen space. It also mentions that collaborative filtering enables the web to adapt to each individual user's needs. The page includes a 'Comments (2)' section with a 'Q&As (2)' tab, showing a question from 'shilei' about 'Adaptive Web and Recommendation Web' and a 'My answer' section. The left sidebar shows the user's profile 'shilei' with 'My modules: Learning 14' and 'Learnt: 7', recommended concepts like 'Explicit v.s. Implicit Ratings' and 'Social Navigation', top users, and study buddies.

The screenshot shows the 'Quiz list' page on the Topolor platform. The page is dated 'Learnt at: Jan 17, 2013'. It features a 'Review the Quiz' button and navigation links for 'Previous' and 'Next'. The main content area includes a 'Tag' section with 'adaptive web', 'comparison', 'explicit', 'limitation', and 'prediction'. The text explains that early collaborative filtering systems were designed to provide users with information about items they visited, and that providers of information on the web must deal with limited user attention and limited screen space. It also mentions that collaborative filtering enables the web to adapt to each individual user's needs. The page includes a 'Comments (2)' section with a 'Q&As (2)' tab, showing a question from 'shilei' about 'Adaptive Web and Recommendation Web' and a 'My answer' section. The left sidebar shows the user's profile 'shilei' with 'My modules: Learning 14' and 'Learnt: 7', recommended concepts like 'Explicit v.s. Implicit Ratings' and 'Social Navigation', top users, and study buddies.

Figure 4 Q&A Centre page

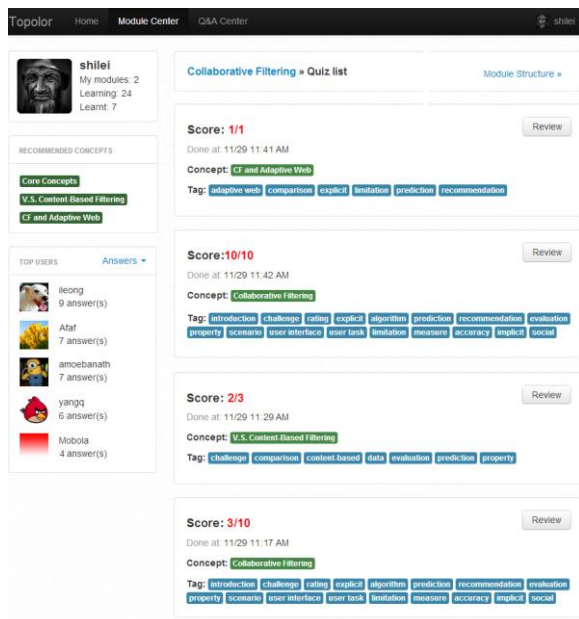


Figure 5 Question list page

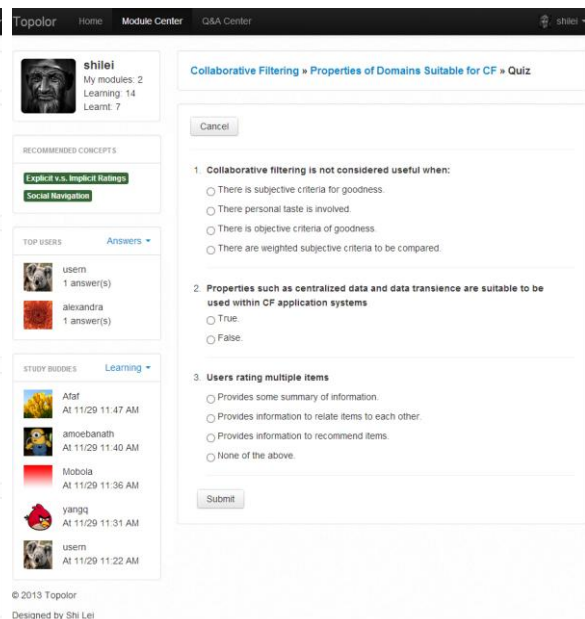


Figure 6 Quiz list page

Figure 7 Quiz page

The social interaction toolset is one of the most important components in Topolor. To provide easy access to social interaction, this toolset can be accessed from many places in the system. For instance,

Figure 8, Figure 9 and Figure 10 demonstrate the social interaction toolset from the top of the Topolor-Home index page (Figure 1).

Figure 11 and

Figure 12 are peer recommendation list where the avatars can be clicked on, so that a messaging box will popup as shown in Figure 13.

This paper focuses on three social interaction tools. The status tool (

Figure 8) is used to share learning statuses. Learners can 'favourite' and comment on each other's posted learning statuses; the messaging tool (Figure 9) is used to send private messages to others; and the Q&A tool (Figure 10) is used to ask and answer questions. Learners can also use Q&A tool for discussions.

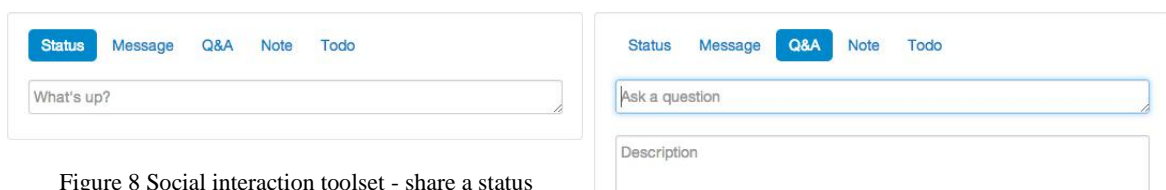


Figure 8 Social interaction toolset - share a status

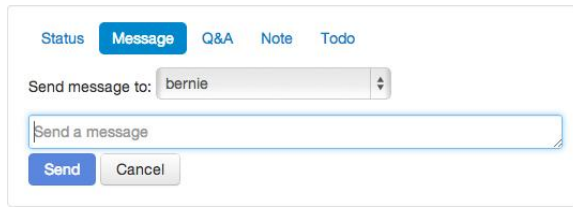


Figure 9 Social interaction toolset – send a message



Figure 10 Social interaction toolset - ask a question

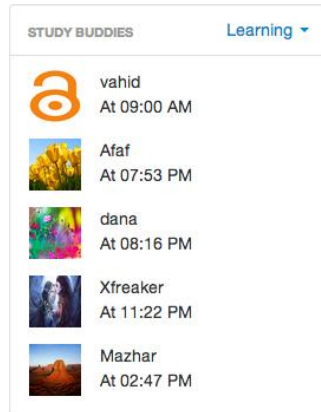


Figure 11 Study buddies list

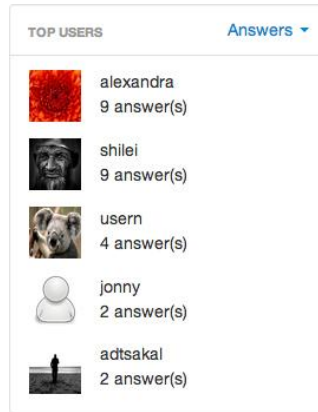


Figure 12 Top user list

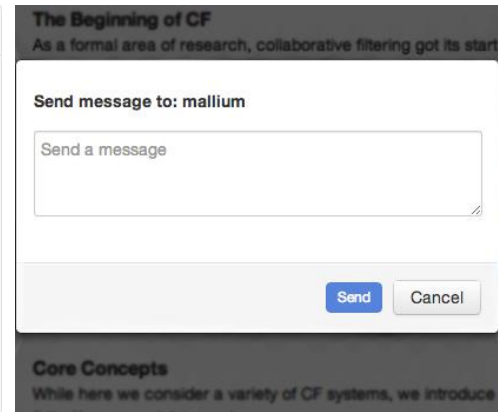


Figure 13 Messaging popup

4. CASE STUDY

In this section, we present the design of the conducted case study, which has been constructed in three consecutive stages: 1) the experiment of using Topolor, 2) the questionnaire about the usefulness and ease of use, and 3) the analysis of the questionnaire results and qualitative user feedback.

4.1 Experiment

The experiment was conducted within a postgraduate level module at the Department of Computer Science, at the University of Warwick. Twenty-one students enrolled in the module of ‘Dynamic Web-Based Systems’, and a lecturer who was leading this module, took part in the experiment. The time-controlled experiment lasted for two hours, during which the students were learning a lesson on ‘Collaborative Filtering’ from Topolor as well as performing specific tasks to familiarize themselves with the features related to the provided social interaction toolset. Before the online learning session, a ‘to-do list’ was handed out to the students, in order to make sure they had a reminder of all features at their disposal. The order of using the features, as well as the choice to use or repeat using any features was up to them. The full list of the 18 social-related features used by the students is listed in Table 1.

Table 1 Social-related features used by the students

Learning Status	Message	Question	Answer
Create (a)	Send (g)	Create (i)	Create (l)
Edit (b)	Reply (h)	Edit (j)	Edit (m)
Remove (c)		Remove (k)	Remove (n)
Comment on (d)		Share (o)	
'Favourite' (e)		'Favourite' (p)	
Share (f)		Add a Tag (q)	

4.2 Questionnaire

Usefulness and *ease of use* are fundamental determinants of user acceptance for a tool usage (Adams *et al.*, 1992; Davis, 1989). After running the experiment, the students were asked to fill in a questionnaire to rate the 18 social-related features, listed in Table 1, in order to measure the *usefulness* and *ease of use* of the social interaction toolset in Topolor. The questionnaire is partially shown in Table 2, which gives an idea of the look and feel of the questionnaire, but not all questions/answers are depicted due to space limitation. Likert scale (McIver and Carmines, 1981) questions were used to get the feedback on all social-related features. The students were asked to select one of the five responses evaluating *usefulness* and *ease of use*.

Table 2 Questionnaire to evaluate social-related features (partial)

Functionality	Usefulness					Ease of Use				
Asking a Question	1	2	3	4	5	1	2	3	4	5
Editing a Question	1	2	3	4	5	1	2	3	4	5
Removing a Question	1	2	3	4	5	1	2	3	4	5
Answering a Question	1	2	3	4	5	1	2	3	4	5
Editing the answers	1	2	3	4	5	1	2	3	4	5
Removing the answers	1	2	3	4	5	1	2	3	4	5
Sharing the Questions	1	2	3	4	5	1	2	3	4	5
...				

The score assigned to each response, on a scale of 1 - 5 as shown in Table 2, is further explained in Table 3. After collecting the questionnaires, the responses of the students were analyzed.

Table 3 Scores assigned to each response in the questionnaire

Usefulness	Ease of Use
1: very useless	1: very hard
2: useless	2: hard
3: neither useless nor useful	3: neither hard nor easy
4: useful	4: easy
5: very useful	5: very easy

5. ANALYSIS AND RESULTS

Out of the 21 students participated in the experiment, 10 of them responded to the optional questionnaire. The number of total questions in the questionnaire was 36, of which 18 questions were for testing *usefulness*, with the other 18 corresponding to *ease of use*. The 18 tested social-related features are shown in Table 1, and labeled a - n. These labels are further used in the following figures.

5.1 Usefulness

Figure 14 shows the mean Likert scale rating for each social-related feature's *usefulness*; Figure 15 shows the standard deviation of each Likert scale rating for each social-related feature's *usefulness*. The *mean* values of the summative results rank between 3.7 and 4.6. The *standard deviation* values of the overall results are

between 0.516 and 0.994. All the reported values of a mean are much larger than 3 (the neutral response), suggesting students' attitudes to be generally positive.



Figure 14 Mean Likert scale rating for each social-related feature's usefulness



Figure 15 Standard deviation of each Likert scale rating on social-related feature's usefulness

5.2 Ease of use

Figure 16 shows the mean Likert scale rating for each social-related feature's *ease of use*, and Figure 17 shows standard deviation of each Likert scale rating on social-related feature's *ease of use*. The *mean* values of the overall results rank between 3.8 and 4.7. The *standard deviation* values of the overall results are between 0.483 and 1.135. All the *means* are greater than 3 (the neutral response), which enables us to infer that most of the students found the social interaction toolset to be relatively *easy to use*.



Figure 16 Mean Likert scale rating for each social-related feature's ease of use

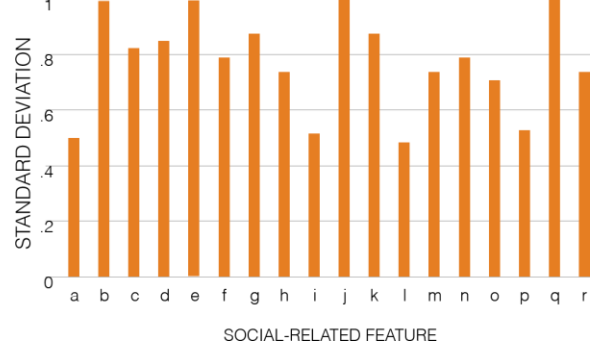


Figure 17 Standard deviation of each Likert scale rating on social-related feature's ease of use

5.3 Reliability

To examine the reliability of the experimental results, we calculated the result's *Cronbach's α* value for each scale item (response for a question), a coefficient of internal consistency (Cronbach, 1951), which is based on the average of all possible split pair correlations of the questions and is a common metric for this form of reliability. The general formula for calculating a *Cronbach's α* value is as Formula (1) (Cronbach and Shavelson, 2004), where k refers to the number of scale items on the test, s_i^2 refers to the variance of scale item i , and s_t^2 refers to the variance of total scores on the text. The standardized *Cronbach's α* value can be

calculated by Formula (2), where K is the number of variables, and \bar{r} is the average correlation among all pairs of variables.

$$\alpha = \frac{k}{k-1} \times (1 - \frac{\sum s_i^2}{s_t^2}) \quad (1)$$

$$\alpha_{standardized} = \frac{K\bar{r}}{(1+(K-1)\bar{r})} \quad (2)$$

A commonly accepted range of the *Cronbach's alpha* value for scale items is shown in Table 4 (George and Mallery, 2003; Kline, 1999).

Table 4 Rule of thumb for describing internal consistency using *Cronbach's alpha*

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent (High-Stakes testing)
$0.7 \leq \alpha < 0.9$	Good (Low-Stakes testing)
$0.6 \leq \alpha < 0.7$	Acceptable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

As presented in Table 5, the *Cronbach's alpha* value and the standardized *Cronbach's alpha* value of each scale item (both for *usefulness* and *ease of use*) reach greater than 0.9, indicating an 'excellent' level of reliability (internal consistency) of the results.

Table 5 *Cronbach's Alpha* values

	<i>Usefulness</i>	<i>Ease of Use</i>
Cronbach's Alpha	.934	.948
Cronbach's Alpha Based on Standardized Items	.944	.957
Number of Items	18	18

6. DISCUSSION

In addition to the questionnaire data collected from the students, we also received some qualitative feedback from both students and the lecturer of the module. The general feedback was consistent with the results of the questionnaire. However, the responses included some specific suggestions for further improving some of the social interaction features, which ranked lower from the point of *usefulness* and *ease of use*. Due to the space limitation, this paper focuses mainly on the quantitative results from the questionnaire. However, some of the qualitative feedback is discussed below as appropriate.

Overall, the results from the questionnaire demonstrate that the social interaction toolset is perceived to be useful and easy to use. 15 out of the 18 features have been rated by the students as useful, and 14 out of the 18 features as easy to use (i.e., mean ≥ 4). The qualitative feedback also indicated that the system is easy to use – for instance, one comment described the system as “similar to known social networking sites (e.g. Facebook); fast and responsive”. Another respondent said: “One of the best aspects of Topolor is the ability to interact with others during the process of learning”. In the following subsections, we proceed to a detailed discussion of the individual social interaction tools, namely *status*, *messaging* and *Q&A*.

6.1 Status

The questionnaire results demonstrate that the feature (d), *commenting on a status*, was rated as the third most useful feature (mean = 4.5), and its *ease of use* was ranked as the fourth highest (mean = 4.5) among all the social interaction features. This result is further supported by the qualitative feedback. For example, one of the respondents explicitly mentioned that commenting on each other's *statuses* was one of his favourite features for interacting with other students. Commenting on a learning status has made the system more appealing to the students, as they haven't experienced such a feature in other e-Learning systems. This therefore combined studying with social networking. Furthermore, the students felt that commenting on a learning status made their learning experience richer in terms of exchanging ideas and knowledge without worrying about the formality of introducing themselves to each other and eliminating the social phobia that some students may experience.

On the other hand, (e) 'favourite'-ing *a status* had the lowest rating (mean = 3.7) on *usefulness*. One of the aims of this feature is so that learning statuses with a large number of 'favourite'-s can be recommended to other students, since the content of the status might be useful. It could be also used in other education scenarios such as suggesting ways of solving questions, and suggesting learning materials. The possible reason for this being the lowest rated feature could be that the students might not have known what the use of 'favourite'-ing a status was, or felt that the feature did not provide them with any personal benefit. We assume that it would be necessary to develop a mechanism for providing basic information on less familiar features such as 'favourite'-ing. Additionally, the fact that the 'favourite' option in Topolor is available within a range of features (such as questions/answers) might also affect the future patterns of use. Furthermore, one possible reason for the second lowest rating on (e) *favoring a status* for its *ease of use* (mean = 3.9), could be that labels for 'favourite'-ing/'unfavourite'-ing statuses became visible only when the status message was being hovered over. The suggested improvement would be to keep the labels and the number of times the statuses have been 'favourite'-d always visible.

6.2 Messaging

The rating for (g), *sending a message* was, whilst high, the second lowest (mean = 3.9) with regards to its *ease of use*. One possible reason for this is that the system currently only notifies the user of new messages when the user is currently viewing the messaging page. Therefore, if the students had not visited the messaging page, they might not have known when and how to start messaging. Additionally, whilst most of the webpages in Topolor provide at least one tool for sending messages to other students, (such as the avatar list of the recommended learning peers (

Figure 11 and

Figure 12) that provided a messaging box (

Figure 13) when the user clicked on a peer), there are still other webpages that did not provide such tools, potentially affecting the results about the *ease of use* of sending messages. However, since messaging is such a vital tool within social media, we consider messaging to be a 'must have' features in Topolor, enabling students to exchange their ideas privately. It also complements the feel and look of Topolor as a social e-Learning system.

6.3 Asking and Answering Questions

The questionnaire results indicated that (l) *answering a question* was rated as the most useful feature (mean = 4.6) as well as the easiest feature to use (mean = 4.7), among all the social interaction features. A similar result was found from the qualitative feedback, where the way of asking and answering questions was explicitly mentioned as favourable. Furthermore, (i) *asking a question* was rated very high on the *usefulness* (mean = 4.5) and *ease of use* (mean = 4.5) scales too. Therefore, we can report with confidence that the students were very satisfied with the features of asking and answering questions.

Nevertheless, the *usefulness* of (r) *editing the tags of a question* was rated as the second lowest (mean=3.8), and the *usefulness* of (q) *adding tags to a question* was rated as the fourth lowest (mean=4.1). One of the original intentions of providing such features was to enable students to label questions for their own reference; hence they will be able to more easily find the specific questions asked before. It seems, however, that *tagging on questions* was not considered as useful as other features of Topolor. We can conjecture that when a student asked a question within the scope of the course, the relation between the question and the learning content

would have been automatically established, so that tagging the question would not have brought additional benefits. Students would need to post questions beyond scope of the course would be necessary to further comment on this feature.

Amongst the *ease of use* of the feature for asking/answering questions, (j) *editing a question* was rated the lowest (mean=3.8). To provide attractive user experiences, we used AJAX calls to implement this feature. For example, when a student clicked on the title or the description of a question, it would activate the HTML 'textarea'; and when the 'textarea' 'focusout'-s, it would be replaced by the updated HTML text. No explicit buttons were provided to trigger editing. This might have not attracted student attention to the existence of this functionality. Although the style of the mouse cursor changes when hovering over the title or the description of a question, this hint might not have been a clear enough indication to the students about the provided editing functionality. Moreover, *editing a question* may require engagement with the system over a longer period of time, so the evaluation of this feature can only be finalized after long term usage of the system.

7. CONCLUSION AND FUTURE WORK

Adaptive Educational Hypermedia Systems (AEHSs) allow personalization of e-Learning. Social media enables learners to create, publish and share content, facilitating interaction and collaboration. Integration of social media tools into AEHSs offers new ways for learner engagement and extended user modeling, thereby creating Social Personalized Adaptive E-Learning Environments (SPAEEs). The overall research goal, therefore, is to improve the learning experience and learning efficiency in SPAEEs via a social adaptive learning paradigm, based on the hypothesis that *extensive social features, personalized recommendations and Facebook-like appearance of a system (anticipated to make the environment more familiar to learners), subsequently increases the usefulness and usability of the system*.

Topolor is a SPAEE that has been under iterative development aimed to test the above hypothesis. The first prototype was used as an e-Learning platform for MSc level students in the Department of Computer Science, at the University of Warwick, and the usage data was anonymously collected for analysis. Besides the evaluation of social interaction features in Topolor, reported in this paper, we have also conducted several other studies on 1) Participatory Design (PD) for a new SPAEE, 2) evaluation of usability of various features in Topolor, and 3) learning behavior pattern analysis in Topolor.

PD is a methodology that engages participants as active members of the design process (Muller, 2003). During design sessions, participants make design decisions by doing design tasks and discussing in a collaborative environment. Students are the core participants in an e-Learning process, so it is essential for the e-Learning environment designers to take into consideration the students' opinions (Shi *et al.*, 2012b). Involving students in the design process brings benefits not only for applications, but also for the students themselves, because it can help exchange knowledge between students and designers (Roda, 2004). As one of the PD methodologies, We!Design 1) conducts co-operation between students and designers in a short period of time; 2) supports a content-independent learning process, including note-taking and assessment, and 3) exploits the potential of highly computer-literate students who are driven to collaborate in order to produce a description of needs, task sequences and user interface prototypes (Triantafyllakos *et al.*, 2008). For these reasons, we chose We!Design at the early stage of designing the first prototype of Topolor, and extracted an ordered list of application requirements (Shi *et al.*, 2012a).

SUS is a ten-item attitude Likert scale (Brooke, 1996) that can give a global view of subjective assessments of usability for a system. In the primary evaluation, the SUS questionnaire was chosen to evaluate the usability of the first prototype of Topolor (Shi *et al.*, 2013g). Topolor was used to teach 'Collaborative Filtering' during a two-hour lecture in the Department of Computer Science, University of Warwick, after which the students were asked to fill in an optional SUS questionnaire. 10 (out of 21) students' responses were received. The SUS score was 75.75 out of 100 ($\sigma=12.36$, median=76.25), and the Cronbach's alpha value of the questionnaire data was 0.85 (>0.8). Therefore, we claimed that the first prototype of Topolor's usability meets our initial expectations. Positive qualitative feedback from the students supported this SUS result.

User modeling is a process where learner's specific needs are built and maintained (Brusilovsky and Millán, 2007), either by explicitly gathering or implicitly obtaining user data during user-system interaction, in order to provide personalized and adaptive services. Using an implicit approach, a SPAEE can track

learning behaviors unobtrusively and ubiquitously, hence inferring unobservable information from observable information about a learner. To provide suggestions on the further development and improvement of implicit user modeling in Topolor, we analyzed learning behavior in the first prototype of Topolor, using the proposed utilization of data mining methods and visualization tools (Shi *et al.*, 2013h). We explored learning behaviors patterns in Topolor, focusing on the analysis of *action frequency* and *action sequence*. The results revealed some interesting individual learning behavior patterns and some common learning behavior patterns, which suggested the possible directions both to improve implicit user modeling for the next prototype of Topolor, and to design user modeling for other SPAEEs.

This paper has introduced Topolor, a social personalized adaptive e-Learning environment, focusing on its social interaction toolset and related features. We have reported the evaluation of Topolor's social toolset on each feature's *usefulness* and *ease of use*, as well as the reliability of the results. Topolor was designed to include a wider range of social interaction features (Table 1) than previous adaptive educational hypermedia systems. The evaluation results indicated students' high satisfactions on both *usefulness* and *ease of use* of the various social features that Topolor provides, with 'excellent' level of reliabilities. The oral feedback was that they would have wanted to have more lessons in this e-Learning environment. Decisive in this, we believe, was the fact that a lot of the social features had a look and feel familiar to them that was similar to the popular Facebook environment. Such familiarity is essential to consider in designing such systems.

Although all the reported mean values are much larger than 3 (the neutral response), we have discussed possible ways to improve these features, in order to improve the social interaction toolset in Topolor further. We reviewed the relatively lower rated features and discussed the possible reasons that might have led to lower ratings. To improve this toolset, we intend to conduct further research based on the presented results and the discussions, particularly in the following areas:

- *'favourite'-ing*. Firstly, we intend to find a better way of 'favourite'-ing and un-'favourite'-ing learning statuses, questions, answers and learning topics. Secondly, we intend to explore how to use this data on 'favourite'-d items for adaptation and personalization. One possible way is to use the data as parameters of the filters that Topolor provides. For instance, learners can 'mark' a question by 'favourite'-ing it, so that they can easily find this marked question later.
- *Status sharing*. We intend to extend the existing mechanism of learning status sharing by introducing support for filtering. The benefits of such a feature will then further be evaluated with respect to how it benefits collaboration. This feature will have the potential to improve the process of locating relevant statuses and communicating with learning peers. As well as allowing learners to post their learning status, Topolor will provide the ability to automatically post learners' activities. For example, learners will be able to see whether learners finished learning a topic 'Just Now', or answered a question '5 minutes ago', etc. This new feature will be expected to stimulate competitive learning (Regueras *et al.*, 2009), which will be evaluated in our next round experiment.
- *Tagging*. Tagging enables learners to connect various concepts within the system (such as topic, questions, learning statuses, etc.). This could be used to enhance recommendation in an adaptive e-Learning system using user-based and item-based collaborative filtering (Sarwar, 2001). However, the results presented in this paper have shown that students are usually reluctant to tag. Considering the importance of tags, we intend to enable Topolor to automatically generate tags according to the content posted.
- *Messaging and notifying*. The next prototype of Topolor will be able to support instant messaging and appropriate notification. Learners will be notified instantly when they receive a message, and will therefore be able to easily reply to the message. They will be also able to receive notifications from Topolor, for example when somebody answers one of their questions. However, we will investigate the impacts brought by the new messaging features, such as if (and how) it can support a collaborative learning process, and if (and how) it can disturb an individual learning process.

The next prototype of Topolor is currently being implemented, based on the analysis of the results reported in this paper. In addition to this, the new version will add other features including 'light gamification' of social interactions. We intend to start with enhancing relatively lower rated social features reported in this paper, by introducing so-called Tip Mechanism, Badge Mechanism and Peer-review Mechanism (Shi, et al., 2013i). Future experiments will focus on the evaluation of the new and improved features. The future evaluation of the enhanced system will enable further enquiry into the role of social interaction in adaptive e-Learning environments, as well as the benefits of enriching *learning experience* and improving *learning efficiency*.

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